

RSR--97-3013-1

HIGH STRENGTH CERAMICS BEARINGS

**INTERIM REPORT
0001AA
N00014-97-C-0375**

PREPARED FOR

Office of Naval Research

September 15, 1997

19970919 012

DI	DITION STATEMENT A
Approved for public release; Distribution Unlimited	

REPORT DOCUMENTATION PAGE

*Form Approved
OMB NO. 0704-0188*

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY <i>(Leave blank)</i>			2. REPORT DATE 13 Sept. 1997		3. REPORT TYPE AND DATES COVERED Progress Report 13 Aug 1997 - 12 Sept 1997	
4. TITLE AND SUBTITLE High Strength Ceramics Bearings			5. FUNDING NUMBERS N00014-97-C-0375			
6. AUTHOR(S) Joseph K. Scharrer						
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Rotordynamics-Seal Research 3628 Madison Ave Suite 20 North Highlands, CA 95660			8. PERFORMING ORGANIZATION REPORT NUMBER RSR 3013-97-1			
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Office of Naval Research 800 North Quincy Street Arlington VA 22217-5660			10. SPONSORING/MONITORING AGENCY REPORT NUMBER			
11. SUPPLEMENTARY NOTES						
12a. DISTRIBUTION/AVAILABILITY STATEMENT				12b. DISTRIBUTION CODE		
13. ABSTRACT <i>(Maximum 200 words)</i> <p>Rotordynamics-Seal Research is currently performing on a 6 month contract to develop high strength ceramic bearings using a new low cost process. This effort consists of development of a ceramic bearing design, fabrication, and testing of the bearing in an existing test rig. This is the first monthly progress report.</p>						
14. SUBJECT TERMS					15. NUMBER OF PAGES 5	
					16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified		18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified		19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified		20. LIMITATION OF ABSTRACT

Monthly Report for N00014-97-C-0375

Progress During Reporting Period

The focus of the effort during the first contract month was design of the angular contact ball bearing. The complete effort consisted of the following:

- completed subcontract with JHU
- design adapter hardware for motor test
- analyze ball bearing for preload and tolerances
- revise bearing race drawings

JHU Subcontract

The subcontract for Johns Hopkins University was completed this month. The negotiations took much longer than anticipated due to a major disagreement over the publication of research results. JHU expected to publish at will without regard for patent issues, trade secrets, or government approvals. This position is typical of universities. All matters have been resolved and the subcontract is in place.

Test Hardware

The final task in this effort will be a simple test of the ball bearing. To accomplish this, the bearing will be mounted on the shaft of a small high speed motor. The conceptual design for this adapter hardware is shown in Figure 1. The bearing will be compliantly mounted on the end of the motor shaft. This will be done to limit stress on the inner race of the bearing and to avoid rotordynamic problems associated with a three bearing rotor. Manufacturing drawings are being completed for the adapter hardware and will be sent out for bids.

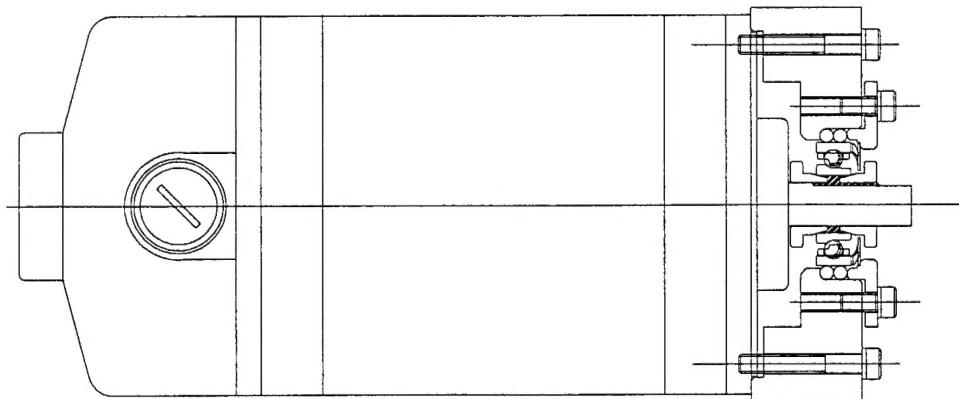


Figure 1. Test set up

Ball Bearing Analysis

RSR's ball bearing analysis code MBZIP was used to analyze the bearing to determine the operating characteristics of the bearing up to 10,000 rpm for 4.448 N (1 lbf) and 22.24 N (5 lbf) axial preload. The bearing operating at a preload of 22.24 N will have a positive axial displacement at speeds up to 10,000 cpm while for the 4.448 N preload the bearing operates at a negative axial displacement at speeds above 9500 cpm.

Table 1 shows the geometry and materials of the bearing to be tested. The outer race is fixed, and the inner race rotates. The bearing will be mounted compliantly; therefore, the stress on the inner race will primarily due to rotational effects. At 10,000 cpm, the stress on the ceramic inner ring will be 0.31 MPa (45 psi). Figure 2 and Figure 3 show the axial displacement and radial stiffness, respectively, for preloads of 4.448 N and 22.24 N. The negative axial displacement and radial stiffness at a preload of 4.448 N precludes using that preload at speeds above 5000 cpm.

Table 1. Geometry and Materials of Ball Bearing

Number of balls	11
Ball diameter, mm (in)	4.7625 (0.1875)
Inner race curvature, %	54.03
Outer race curvature, %	54.03
Pitch diameter, mm (in)	23.48 (0.9246)
Contact Angle, degrees	15.0
Ball material	Silicon Nitride
Ball elastic modulus, GPa (psi)	310 (45E6)
Ball density, g/cm ³ (lb/in ³)	3.2 (0.116)
Race material	Silicon Carbide
Race elastic modulus, GPa (psi)	393 (57E6)

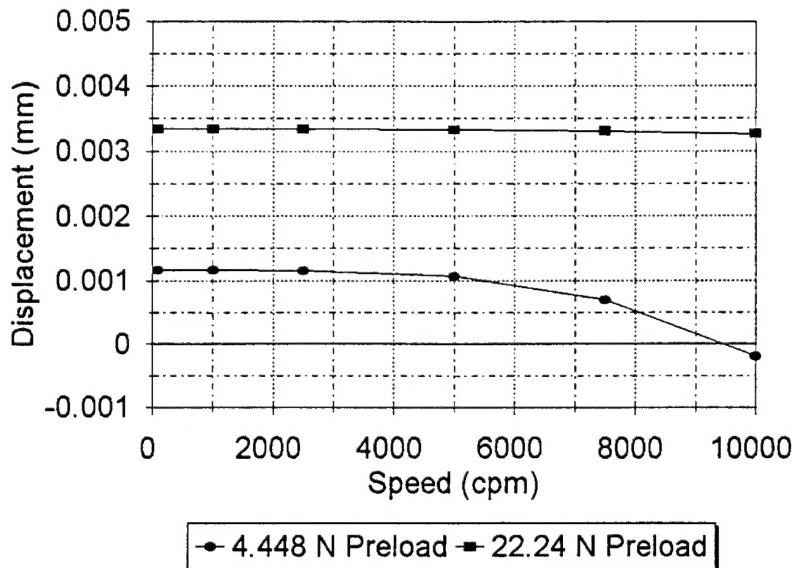


Figure 2. Axial displacement versus rotational speed

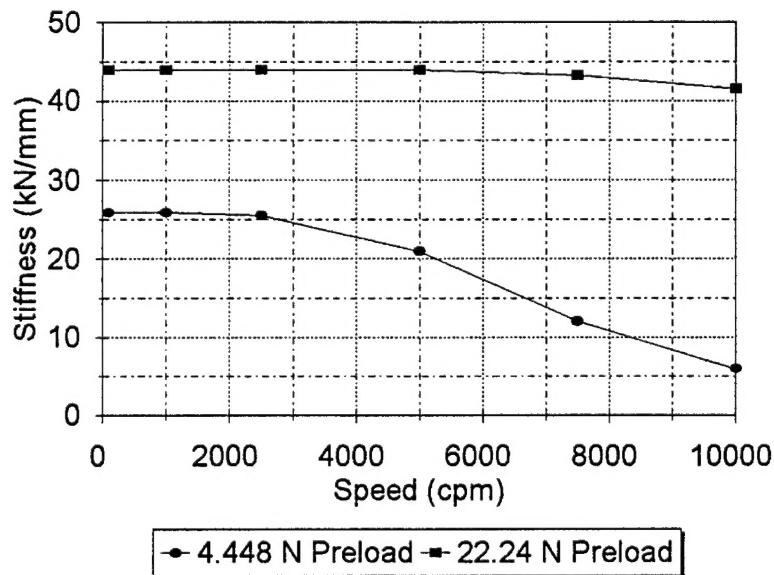


Figure 3. Radial stiffness versus rotational speed

Bearing Race Drawings

Bearing race drawings were obtained from the Barden Company for a hybrid ceramic ball/metallic race bearing. Based on the aforementioned analysis, the drawings were revised to fit the test set up and to ease some tolerances (mainly axial length). The final drawings are shown in Figures 4 and 5.

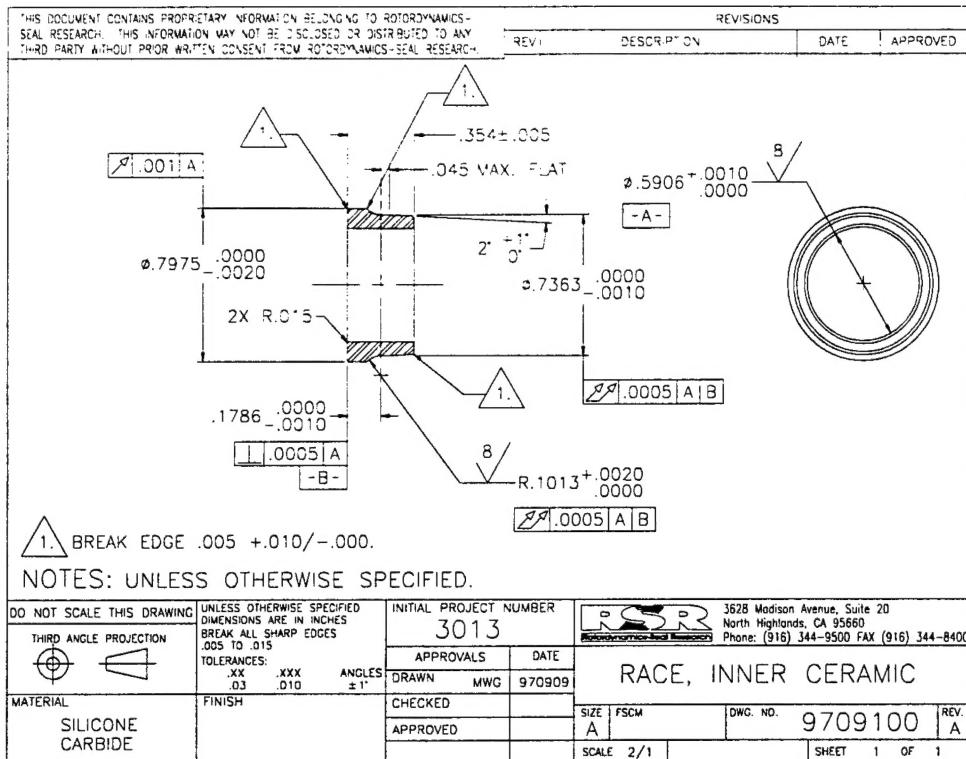


Figure 4. Inner race drawing

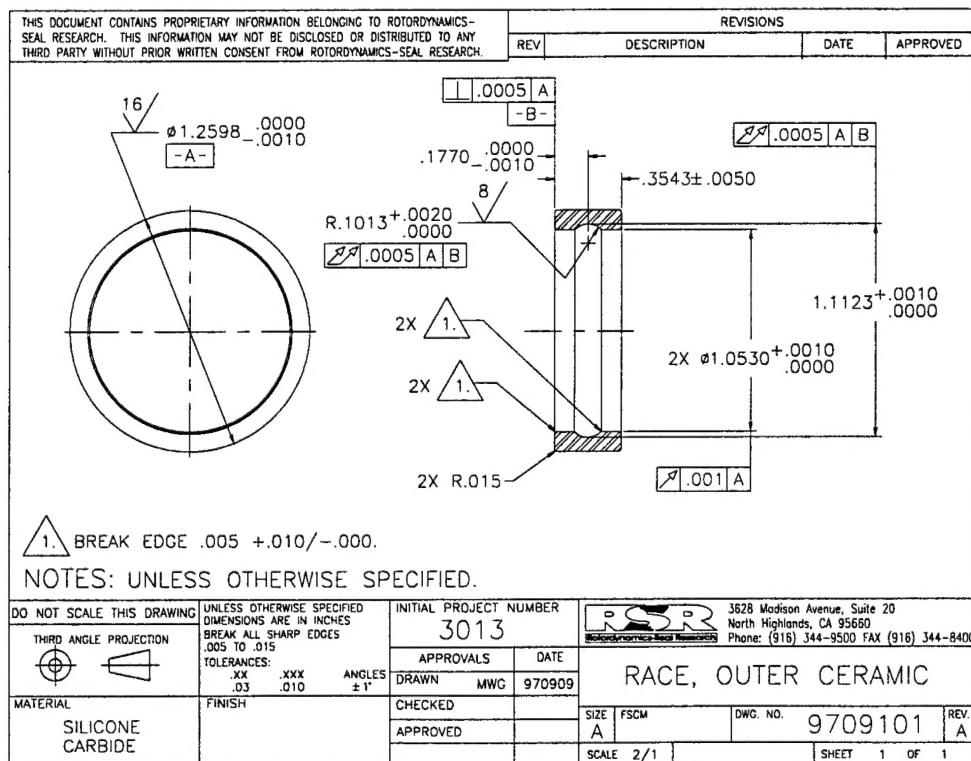


Figure 5. Outer race drawing

Work To Be Performed For The Next Reporting Period

The following effort will be reported on for the next reporting period:

- initiate fabrication of adapter hardware
 - begin development of ceramic races at JHU

Cost And Schedule Status

During the first month of the contract effort \$6,132.60 was expended for labor \$53,812.40 will be required for completion. Approximately 19.13% of the labor has been completed.

TASK	Month from Go-ahead					
	1	2	3	4	5	6
Bearing Design						
Bearing Fabrication						
Bearing Test						
Reporting						

Potential Problem:

No problems at this time.

Please feel free to contact me if you have any questions concerning this report.

Sincerely,

Joseph K. Scharrer, Ph.D.
President